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ELECTRICAL RECORDING PEN

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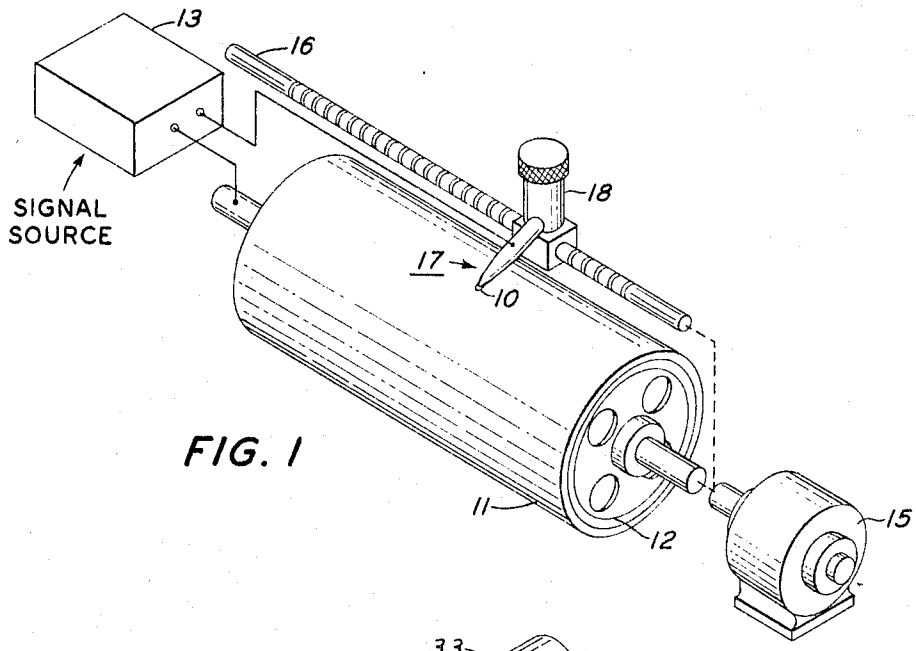

FIG. 1

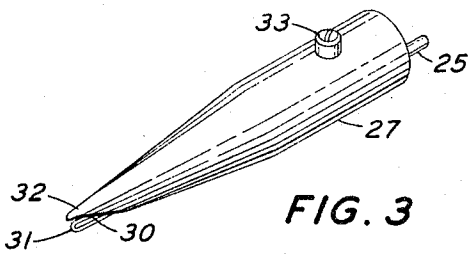

FIG. 3

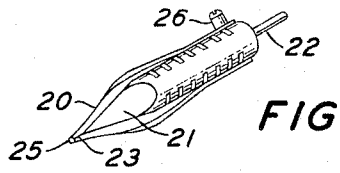

FIG. 2

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ELECTRICAL RECORDING PEN

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This invention relates to electrostatic recording and in particular to recording with a liquid ink responsive to an electrical signal.

Liquid ink recording devices generally fall into one of three categories:

A first category is that in which physical contact between the ink fed stylus and the recording surface is physically interrupted in accordance with a signal. Interruption of physical contact is hard to control at high speeds and with a fast flow of intelligence requires a highly-damped nonelastic mechanical system. The large amount of distortion-free power required to operate such a system at speeds of 10 kc. or higher results in high initial cost and a very low level of operating efficiency.

A second category may be called ink spitters and includes devices in which ink is transferred across a gap from a point or orifice onto the recording surface responsive directly to an electrical force or to controlled pressure in the feed system. Ink spitters are limited by the energy requirements to move a particle across a gap. Factors such as inertia and surface tension must be overcome, both being extremely difficult at high frequency rates. For example, in droplet sizes suitable for recording purposes, it is estimated that the potential required to move drops across a one mil gap at 10 kc. is in the range of 30,000 volts per cm. which is also about the potential required to produce undesirable air breakdown. If it is also necessary to completely overcome surface tension by electrical potential, the usable frequency is greatly reduced.

The third category is one in which an ink fed stylus is maintained in constant contact with the recording sheet and is moved relative to the recording sheet in order to record information. Like the first category, this third one provides a continuous mark on the recording surface at all times when the stylus and recording surface are in contact. This last category has been limited pretty much in practical application to oscillographic use since it becomes quite complex to control a continuously marking stylus through the tortuous configuration necessary for more sophisticated writing.

It becomes apparent that a device in which the stylus remains in continuous contact while ink is transferred only on command could approach the ideal. The expert in the art immediately realizes, however, that the characteristics for providing ready flow of ink on command are the same as those for providing continuous flow from a stylus to a relatively moving, contacting surface. These same characteristics are just the opposite of those desirable for fast interruption of ink flow on command. One attempt at circumventing this problem is disclosed in U.S. Patent 1,550,048 wherein an ink is used that is colorless until an electric current is passed through it. The ink flows continuously to the recording surface, but becomes strongly visible only when exposed to an electric current as it leaves the stylus. The resolution achieved by this method was too low for high speed recording purposes.

Now in accordance with the present invention, the mutual incompatibility of fast turn-on and interruption of ink flow from a stylus in continuous contact has been overcome. This has been effected by the direct application of a high voltage signal across the recording stylus and the recording sheet in combination with slight modifications in the tip of conventional styli to permit rapid interruption of ink flow. Thus, it is an object of the present invention to define a novel high speed liquid ink recording device.

It is a further object of the present invention to define a method of selective liquid transfer between a stylus and a recording surface in continuous physical contact.

Further objects and features of the invention will become apparent upon reading the following description in connection with the drawings wherein:

FIGURE 1 is an isometric drawing of recording apparatus in accordance with the invention.

FIGURE 2 is an isometric drawing of a recording stylus in accordance with the invention.

FIGURE 3 is an isometric drawing of a second embodiment of a recording stylus in accordance with the invention.

A review of the ink pen art shows that the common feature used to ensure a continuous uniform ink flow during writing is a capillary. In operation, the orifice of the capillary is positioned in contact with a moving surface. For quick interruption of flow in the present invention, the orifice of the capillary is kept out of contact with the moving surface. With no contact to a capillary orifice, the moving surface pulls ink from the stylus tip at a rate greater than normal flow. Under this condition, the ink stream pinches off and surface tension prevents further flow. Application of a high voltage will overcome surface tension, and cause ink flow on command. A more thorough discussion of stylus theory is given following a detailed description of the recording apparatus and styli illustrated in the drawing.

FIGURE 1 illustrates apparatus for providing high relative speed between an ink carrying stylus **10** and a recording sheet **11**. The recording sheet is a sheet of paper, sheet of plastic, or other material preferably having a resistivity of 1000 ohms./cm. or higher. This resistivity is in order to prevent excessive current drain through the paper, and thus an undue load on a signal source as will be further described. Recording sheet **11** is appropriately mounted on a conductive drum **12**. While signal source **13** applies the recording potential between stylus **10** and drum **12**, motor **15** rotates drum **12** providing motion between the recording sheet and the stylus. The same motor **15** drives feed screw **16** upon which recording pen **17** carrying stylus **10** is mounted so as to drive stylus **10** across the surface of the recording paper in a direction perpendicular to the rotational path of the drum.

Ink is fed to pen **17** from reservoir **18**. The ink is not critical and various commercial ink preparations have been used successfully. The viscosity of the ink may be varied over a wide range.

Recording pen **17** is mounted so as to apply a pressure in the range of .05 lb. to .1 lb. between stylus **10** and recording sheet **11**. The optimum pressure is higher with larger stylus contact area, harder recording sheet material and smaller signal voltages, and lower under the reverse conditions. Writing has been produced with just bare contact with virtually no pressure; however, the results tended to be erratic.

The applied signal voltage can be A.C. or pulsed D.C. and has a preferred range of 800–1500 volts. Higher density and greater uniformity are achieved as the voltage is increased toward 1500 volts. Over 1500 volts, the electrical components become substantially more expensive and the choice of recording sheet material becomes critical to avoid dielectric breakdown. The threshold for ink deposition using three mil common paper for recording is about 200 volts. This varies with conductivity and thickness of the paper. The electric current is a more significant figure and may range

from about 0.5 microampere to 5 microamperes for continuous writing with a direct current potential disclosed in Wise et al. Patent U.S. 2,173,741. Note, however, Wise et al. is quite distinct in specifying no physical contact and in using a powder instead of a liquid.

FIGURES 2 and 3 show stylus configurations that have been found operative for the present invention. The stylus of FIGURE 2 is roughly equivalent to a fountain pen point. Nib **20** is positioned against ink distributor block **21**. Ink is fed from an ink reservoir through supply line **22** into grooves (not visible) in block **21** extending along the surface contacting nib **20**. These grooves fill with ink and serve as an auxiliary ink reservoir to maintain a large supply of ink adjacent to the tip of the stylus. Slit **23** in the nib serves to carry ink from the distributor block to the tip of the stylus utilizing capillary effect.

If slit **23** extended to writing surface **25** on the tip of the stylus, then this stylus would operate in the manner of a conventional fountain pen point and capillary effect would make it impossible to turn the ink flow to the recording sheet on and off at the high frequencies of the present invention. In order to prevent direct capillary flow to the recording sheet, slit 23 in the nib terminates immediately prior to writing surface **25**. It is important that a ready flow of ink be provided to a point just adjacent to the writing surface and that there is no capillary contact to the recording sheet.

In the stylus of FIGURE 2, the nib may be completely formed and then a partial slit cut into it terminating ahead of the writing surface. It may also be made by cutting the slit in the nib right to the end and then bonding a special alloy or jewel tip onto the point blocking off the capillary slit at the same time. As the writing surface of the stylus wears, it normally changes the area of contact, making adjustments necessary in order to maintain print uniformity. Thus, the use of a special hard alloy or jewel at the tip is desirable to minimize wear.

Electrical terminal **26** is provided on nib **20** for connection to a signal source.

The stylus of FIGURE 3 has a hollow body **27** which is supplied with ink through a supply line **28**. Body **27** is shaped to form restricted orifice **30** at the writing end. Extending from body **27** adjacent to said orifice is a wire loop **31**. This wire is about 0.005 in diameter and is bent with a radius of 4 mils. An extended portion **32** of body **27** overhangs loop **31** so that orifice **30** is bounded by loop **31** and extended portion **32**. The orifice, wire and ink surface tension are selected so that ink will fill the space between the wire and the overhang without flowing freely from the stylus. The end of the bent loop in wire **31** prevents the ink from flowing continuously onto a recording sheet when the wire is moved relatively in contact therewith. Optimum operation is obtained with the plane of the loop at an angle of about 45° with respect to the recording surface. Electrical terminal **33** is provided on body **27** for connection to a signal source.

Liquid ink marking devices conventionally use capillaries for insuring uniform continuous flow of ink. In the ball point pen a capillary is used to feed the ball. In regular fountain pens, the slit in the nib serves as a capillary. Some pens in automatic recording devices utilize a capillary tube running their entire length. In all these devices, ink is carried continuously from the capillary by a surface moving in direct contact with the capillary orifice. Capillary effect insures continuous uniform flow and such flow is not readily interrupted unless either the contact or relative motion is interrupted. The stylus in the present invention is designed so that no surface moves in direct contact with a capillary orifice. Where a capillary is used, as in FIGURE 2, it is terminated prior to contact with a relatively moving surface. Thus, a stylus for use in the present invention will not supply a continuous flow of ink to a relatively moving surface. Instead, the flow of ink is dynamically controlled by an electrical signal. It is believed that the principal moving force is coulomb attraction. Interruption of flow when the electrical signal is terminated is attributed to a shearing action of the ink between the recording surface and the pen tip which permits pinchoff and prevention of further flow due to surface tension.

Following are some examples of specific parameters which produced good printout.

Example I

A wire loop pen was supplied with ink made by mixing 50–50 by volume "Skrip" #34 jet black available from the W. A. Sheaffer Pen Company with John R. Bourne Company, black stamp ink available from John R. Bourne Company, Rochester, New York. Calendered sulfite paper was wrapped around a metal drum and revolved against the pen at speeds of 80 in./sec. and 164 in./sec. The pen was then pulsed relative to the drum with 800 volt pulses at a rate of 20,000 cycles per second.

Example II

A pen similar to that of FIGURE 3 was supplied with ink made by mixing 10 grams of monastral green B to 40 grams of light mineral oil. Zinc oxide coated paper was wrapped around a conductive drum and revolved against the pen at a relative speed of 80 in./sec. while the pen was pulsed with 1500 volts at a rate of 20 kc.

Example III

This was the same as Example II using an 82% solution of alkyl phenyl polyglycol ether colored with methyl violet as the ink.

Example IV

Using the ink mixture and pen of Example I, the relative speed of paper and pen was tried at 164, 226 and 360 in. per sec. with an 800 volt pulsing signal of 30 kc. The papers used for this example were "Lee Pro" proofing paper; "Kromekote" paper and polyethylene coated paper.

Example V

This was the same as Example IV using a 2% solution of Acid Fuchsin dye in ethyl alcohol.

While the present invention has been described as carried out in specific embodiments thereof, there is no desire to be limited thereby, but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. A recorder comprising:

(a) a liquid reservoir containing a quantity of liquid recording ink;

(b) an electrically conductive stylus terminating at one end in an integrally continuous writing tip capable of retaining a quantity of liquid ink continuously thereat;

(c) means to supply liquid ink from said reservoir to the writing tip of said stylus and including capillary means extending to near said writing tip but terminating prior thereto;

(d) electrically conductive means to support a recording surface in physical contact with the writing tip of said stylus;

(e) means to provide relative motion between said stylus and a recording surface on said means to support; and,

(f) electrical signal means to apply an electrical potential between said means to support and said stylus to effect in response to said signal a selective transfer of liquid ink from said stylus to a recording surface on said means to support.

2. An electrical signal operated ink pen comprising:
(a) a liquid reservoir containing a quantity of liquid recording ink;
(b) a stylus having an integrally continuous writing tip capable of retaining a quantity of liquid ink continuously thereat;
(c) means to transport ink from said reservoir to said tip and including capillary means extending to near said writing tip but terminating prior thereto;
(d) means to support said tip in continuous contact with a relatively moving recording surface; and
(e) means to apply an electrical signal across said tip and said surface to effectively cause movement of ink from said tip to said surface until application of the signal is terminated.

3. A pen according to claim 2 in which said means to transport ink comprises at least one slit in said writing tip defining the termination of said capillary means.

4. A pen according to claim 2 in which said means to transport ink also includes pressure means to apply pressure to the liquid being transported.

5. Facsimile recording apparatus comprising:
(a) electrically conductive support means adapted to transport a recording sheet on which a facsimile recording is to be made;
(b) a pen having a stylus with an integrally continuous writing tip capable of retaining a quantity of liquid ink continuously thereat and mounted relative to said support means so that the stylus of said pen continuously contacts a recording sheet on said support means with a pressure of at least 0.05 lb.;

(c) an ink supply reservoir for feeding liquid ink to the stylus of said pen and including capillary means extending to near said writing tip but terminating prior thereto; and,
(d) means to apply an electrical signal of facsimile intelligence between said pen and said support means to effectively transfer ink to a recording sheet on said support means for the duration of the applied signal.

6. Apparatus according to claim 5 in which said stylus writing tip comprises a bent wire forming a loop in which ink is retained.

7. Apparatus according to claim 5 in which said stylus writing tip is formed of an elongated writing nib narrowing to a writing point at the tip.

8. Apparatus according to claim 7 in which said nib defines a slit therein comprising the termination of said capillary means.

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